PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-158191
(43)Date of publication of application : 31.05.2002

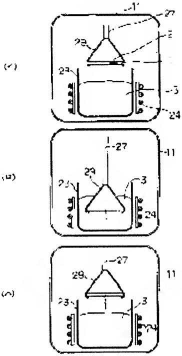
(51)Int.Cl. H01L 21/288
H01L 21/3205

(21)Application number : 2000-355725
(22)Date of filing : 22.11.2000

(71)Applicant : FUJIKURA LTD
(72)Inventor : SUEMASU TATSUO
SATOU AKINOBU
TAKIZAWA ISAO
ITOI KAZUHISA

(54) APPARATUS AND METHOD FOR FILLING METAL IN INFINITESIMAL SPACE

(57)Abstract:
PROBLEM TO BE SOLVED: To enable filling of metal in fine pores of a high aspect ratio perforated in a silicon substrate or the like.
SOLUTION: A method for filling the metal in the fine pores comprises the steps of inserting, for example, the silicon substrate 1 having the pores 2 into a molten metal tank 23 in a vacuum chamber 11 pressure-reduced in a vacuum pressure, pressurizing the chamber 11, for example, to an atmospheric pressure or more after the substrate 1 arrives at substantially the same temperature as that of the substrate 1, and filling a molten metal 3 in the pores 2. The metal can be filled even in the pores of the high aspect ratio, and can be filled without generating an air gap such as a porosity or the like. When the metal is filled in the through pores for through electrodes, the good electrodes having no air gap can be formed.



CLAIMS

[Claim(s)]
[Claim 1]A metal filling apparatus to detailed space characterized by comprising the following.
A vacuum chamber.
A decompressing means for decompressing inside of said vacuum chamber to vacuum pressure.
A molten-metal tub arranged in said vacuum chamber.
An arm for work immobilization for clamping a heater for carrying out heat melting of the metal in said molten-metal tub, and a work with detailed space which it is going to fill up with metal, and inserting into a molten-metal tub in said vacuum chamber, A force means for pressurizing inside of a vacuum chamber more than atmospheric pressure, after inserting a work into a molten-metal tub.

[Claim 2]A metal filling apparatus to the detailed space according to claim 1 having formed an opening and closing cover of a hinge style in an upper face part of a vacuum chamber, and providing an arm supporting part which supports a shank of said arm for work immobilization in a mode which penetrates said opening and closing cover so that a slide is possible in said opening and closing cover.
[Claim 3]Are the method of filling up with metal detailed space formed in a work, decompress first ambient pressure of a work which it is going to fill up with metal, and, subsequently a reduced pressure state has been maintained. A metal filling method to detailed space said work is inserted in molten metal, pressurizing ambient pressure of said molten metal subsequently, filling up said detailed space with molten metal according to an ambient pressure difference before and behind metal insertion, pulling up a work from a molten-metal tub, and cooling it subsequently.
[Claim 4]Said detailed space formed in said work is micropore or an opening, Accommodate said work in a vacuum chamber and, subsequently to vacuum pressure, inside of a vacuum chamber is decompressed, Subsequently, a metal filling method to the detailed space according to claim 3 which inserts said work in a molten-metal tub in a vacuum chamber, pressurizes inside of a vacuum chamber more than atmospheric pressure after a work reaches the same temperature as molten metal, subsequently pulls up a work from a molten-metal tub, and is characterized by carrying out air cooling.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field belonging to an invention] This invention relates to the metal filling apparatus and metal filling method to micropore which fill up with metal the micropore of a high aspect ratio which opened especially in the silicon substrate etc. about the metal filling method and metal filling apparatus of detailed space, for example, micropore, a detailed crevice, etc. which were formed in the work.
[0002]
[Description of the Prior Art]As a case where metal restoration is conventionally carried out to the detailed space formed in the workpiece (henceforth a work), For example, when a penetrating electrode (beer hall electrode) is formed in a silicon substrate by the manufacturing process of a silicon IC chip etc., Plating which opens the breakthrough for penetrating electrodes in a silicon substrate, inserts this silicon substrate in the molten metal (plating solution) to which melting of the metal for conductors was carried out, and is filled up with molten metal in a breakthrough is common.
[0003]
[Problem(s) to be Solved by the Invention]however, since micropore is deep and the until penetration of the molten metal cannot be carried out, when a breakthrough is the micropore of a high aspect ratio (hole depth / opening diameter), For example, as shown in drawing 7, the molten metal 3 focuses near the entrance of the micropore 2 of the silicon substrate 1, grow up, and an opening produces inside, or, Since uniform metal restoration without an opening -- ** (**) 4 is made to the molten metal 3 in the micropore 2 -- was not able to be performed as shown in drawing 8, it was difficult to create a good penetrating electrode.
[0004]By the way, if it, for example, tries to perform high-density three-dimensional mounting which laminates a silicon IC chip, it may be necessary to form the penetrating electrode for connecting the circuit pattern formed in the rear surface of the silicon substrate of one sheet but, and, Since the breakthrough which opens in a silicon substrate will turn into micropore which is a high aspect ratio deeply if it is going to form this penetrating electrode by the above-mentioned conventional method, it is difficult as above-mentioned to fill up metal into this micropore with plating, and to form a penetrating electrode.
[0005]This invention was made in light of the above-mentioned circumstances, and an object of this invention is to provide the metal filling apparatus and method of making it possible to fill up with metal without an opening the detailed space formed into works, such as a silicon substrate, for example, micropore.
[0006]
[Means for Solving the Problem]Claim 1 this invention which solves an aforementioned problem is characterized by an invention of a metal filling apparatus to detailed space comprising the following.

in order to decompress inside of a vacuum chamber and said vacuum chamber to vacuum pressure. Decompressing means.
A molten-metal tub arranged in said vacuum chamber.
A heater for carrying out heat melting of the metal in said molten-metal tub.
An arm for work immobilization for clamping a work with detailed space which it is going to fill up with metal, and inserting into a molten-metal tub in said vacuum chamber, and a force means for pressurizing inside of a vacuum chamber more than atmospheric pressure, after inserting a work into a molten-metal tub.

[0007]In a metal filling apparatus to detailed space of claim 1, claim 2 formed an opening and closing cover of a hinge style in an upper face part of a vacuum chamber, and provided an arm supporting part which supports a shank of an arm for work immobilization in a mode which penetrates said opening and closing cover so that a slide is possible in said opening and closing cover.
[0008]Claim 3 is the method of filling up with metal detailed space formed in a work, decompress first ambient pressure of a work which it is going to fill up with metal, and, subsequently a reduced pressure state has been maintained. Said work is inserted in molten metal, subsequently ambient pressure of said molten metal is pressurized, said detailed space is filled up with molten metal according to an ambient pressure difference before and behind metal insertion of a work, and subsequently, a work is pulled up from a molten-metal tub, and is cooled.
[0009]In claim 3, said detailed space formed in a work claim 4, Are micropore or an opening and said work is accommodated in a vacuum chamber, Subsequently, inside of a vacuum chamber is decompressed to vacuum pressure, subsequently to a molten-metal tub in a vacuum chamber said work is inserted, after a work reaches the same temperature as molten metal, inside of a vacuum chamber is pressurized more than atmospheric pressure, subsequently, a work is pulled up from a molten-metal tub, and air cooling is carried out.
[0010]
[Embodiment of the Invention]Hereafter, an embodiment of the invention is described with reference to drawing 1 - drawing 6. Drawing 1 is a partial notching front view of the important section of the metal filling apparatus 10 of one embodiment of this invention. In the figure, 11 is a vacuum chamber. The vacuum chamber 11 is connected to the vacuum pump apparatus 14 via the siphon 13 which is connected to the opening 11a of a pars basilaris ossis occipitalis, and has the valve 12 for vacuum opening and closing on the way. The vacuum chamber 17 for buffers which is open for free passage by the opening 16 which can be opened and closed by the shutter 15 is formed in the upper part of the vacuum chamber 11. This vacuum chamber 17 for buffers is also connected to said vacuum pump apparatus 14 via the siphon 18 for vacuum rough length with the valve 18a for vacuum rough length. The shutter opening-and-closing mechanism for opening and closing the shutter 15 by the operation from the outside omitted the graphic display. The vacuum chamber 11 and the vacuum chamber 17 for buffers are connected to the nitrogen gas cylinder which is not illustrated as a force means which pressurizes an inside more than atmospheric pressure, respectively via the nitrogen introducing pipes 19 and 20 with the valves 19a and 20a for nitrogen introduction. The vacuum chamber 11 is formed on the case 21 which provided the power supply which operates this metal filling apparatus 10, and control and a final controlling element.
[0011]The molten-metal tub 23 is arranged in said vacuum chamber 11, and the heater 24 for carrying out heat melting of the metal in the molten-metal tub 23 to the surface part is formed. 3 shows molten metal. It is the structure which formed the work clamp 29 at the tip of the arm 27 for work immobilization and the long shank 28 which grasp the work 1 with the micropore which it is going to fill up with metal, In the mode which penetrates the opening and closing cover 30 to the arm supporting part 31 provided in the opening and closing cover 30 of the hinge style provided in the upper face part of the vacuum chamber 17 for buffers, the shank 28 of the arm 27 for work immobilization is supported so that a slide is possible. The atmospheric-air-introduction valve 32

and the relief port 33 are established in the opening and closing cover 30.
[0012]With reference to the procedure filled up with metal, the above-mentioned metal filling apparatus 10 also explains drawing 2 (b), (**), and (**) to the micropore which opened in the silicon substrate etc. Where the shutter 15 is shut, the opening and closing cover 30 is opened so that the vacuum chamber 11 may not be directly open for free passage with the atmosphere. Where the opening and closing cover 30 is opened like the two-dot chain line of drawing 1, for example, it has the micropore 2, the silicon substrate (work) 1 is grasped by the work clamp 28 of the arm 27 for work immobilization. The shank 28 of the arm 27 for work immobilization is made to project greatly from the surface of the opening and closing cover 30, and the work clamp 29 is made to approach the inner surface of the opening and closing cover 30 in this stage. Subsequently, the opening and closing cover 30 is rotated like an arrow, and it shuts, and binds tight and seals with the bolt 34. Subsequently, vacuum chamber 17 inside for buffers is vacuum-rough-lengthened via the siphon 18 for vacuum rough length with the vacuum pump apparatus 14. Subsequently, the shutter 15 is opened. Subsequently, open the valve 12 for vacuum opening and closing, and the vacuum pump apparatus 14 is operated, Vacuum suction of the inside of the vacuum chamber 11 and the vacuum chamber 17 for buffers is carried out via the siphon 13, and it decompresses to a vacuum pressure 10^{-2} - 10^{-3}Pa (Pascal) grade (this stage is shown in the drawing 2 (**)). The vacuum pressure sensor 36 detects vacuum pressure.
[0013]Subsequently, it heats with the heater 24, melting of the metal in the molten-metal tub 23 is carried out, and the silicon substrate 1 is inserted into the molten metal 3. Although it is good to use metal with comparatively low steam pressure, such as eutectic solder of indium, tin, or golden-tin, as metal with which it is filled up, it is not limited to them in particular. It waits enough after insertion until the silicon substrate 1 reaches the same temperature as the molten metal 3. Then, the valves 19a and 20a for nitrogen introduction are opened, nitrogen from a nitrogen gas cylinder is introduced in the vacuum chamber 11 and the vacuum chamber 17 for buffers, and an inside is pressurized to a 2 - 5×10^5Pa (2 - 5 kgf/cm^2) grade. This application of pressure is filled up with the molten metal 3 in the micropore 2, as typically shown in drawing 3 (this stage is shown in the drawing 2 (**)).
[0014]Then, the silicon substrate 1 is pulled up from the molten-metal tub 23 (this stage is shown in the drawing 2 (**)), it takes out besides the vacuum chamber 11, and air cooling is carried out at a room temperature. Thereby, the metal filling work to the micropore 2 of the silicon substrate 1 is completed.
[0015]The example which filled up the micropore of each following work with metal using the above-mentioned metal filling apparatus 10 is shown in drawing 4 - drawing 6. Drawing 4 - drawing 6 sketch the microphotograph of the section for the detailed pore filled up with metal. The example shown in drawing 4 is restoration of the tin 3 to the micropore 2 15 micrometers in diameter, and 360 micrometers in depth (aspect ratio 24) formed in the silicon substrate 1. The micropore 2 was formed on the silicon substrate with photoelectrical solution grinding method. It fills up with the tin 3 that there is no opening in the micropore 2 as the graphic display. Silicon oxide is formed in the inner surface of a breakthrough although not illustrated in particular.
[0016]The example shown in drawing 5 is restoration of the tin 3 to the micropore 2 40 micrometers in diameter, and 100 micrometers in depth (aspect ratio 2.5) formed in the silicon substrate 1. The micropore 2 was formed on the silicon substrate by ICP-RIE (Inductively Coupled Plasma-Ractive Ion Etching). It fills up with the tin 3 that there is no opening in the micropore 2 as the graphic display.
[0017]The example shown in drawing 6 is restoration of the tin 3 to the micropore 2 0.1 mm in diameter, and 35 mm in depth (aspect ratio 350) formed in the glass rod 1. It fills up with the tin 3 that there is no opening in the micropore 2 as the graphic display.
[0018]The metal restoration which metal restoration is possible and openings, such as ** (**), do

not produce to the micropore of a high aspect ratio like each of above-mentioned examples by this invention is possible. Although the example which fills up metal with each example into the micropore which has not been penetrated was shown, metal restoration is still easier if it is a breakthrough. Therefore, when forming a penetrating electrode in a silicon substrate etc., a penetrating electrode without an opening can be manufactured.

[0019]Since the vacuum chamber 17 for buffers which is open for free passage to the vacuum chamber 11 via the opening 16 which can be opened and closed in the above-mentioned metal filling apparatus 10 not only by the vacuum chamber 11 which arranges the molten-metal tub 23 but by the shutter 15 is formed, Without putting the vacuum chamber 11 to the open air directly, it can carry out to above-mentioned metal filling work, therefore the molten metal 3 in the molten-metal tub 23 can prevent touching on the open air and oxidizing certainly.

[0020]Although metal restoration is carried out to the micropore which opened in a silicon substrate or glass in the example described above, the resin etc. which are comparatively excellent in heat resistance and do not melt in metal melting temperature, such as ceramics, Teflon (registered trademark) (fluoro-resin), polyimide, are employable as other work materials. Incidentally, the melting temperature of tin will become applicable [this invention], if it is construction material which does not melt easily in metaled melting temperature in this way, although the melting temperature of about 230 ** and indium changes [the melting temperature of about 157 ** and golden-tin] with ratios into a metaled ratio. Since this invention carries out metal restoration to detailed space according to the ambient pressure difference before and behind metal insertion, existence of a pressure differential is important and the absolute value of order ambient pressure is not limited to an example. It is not limited to the micropore in the silicon which regards as the detailed space in this invention formed in the work in a section which is illustrated, and is straightly prolonged to one way. For example, also when the hole is crooked on the way, it can apply. For example, in the multilayer substrate which laminated two or more silicon substrates as a tabular work, although there is also a pattern in which a hole is crooked on the way along the inner surface of a work (seeing from a section), according to [such even case] this invention, the metal restoration to a crookedness hole is attained. Also when the section outline of a hole branches into arborescence, the metal restoration to an arborescence tip part is possible. According to this invention, the metal restoration to a crevice is also attained. For example, in the work which consists of a structure of composite or a single member combined and depended, when carrying out metal restoration to the detailed crevice (gap) formed into these works, it can apply.

[0021]

[Effect of the Invention]According to this invention, the detailed space of various sections in various works can be filled up with metal. Insert in a molten-metal tub the silicon substrate which has micropore especially, a glass material, etc. within the vacuum chamber decompressed to vacuum pressure, and after these reach the almost same temperature as molten metal, the inside of a vacuum chamber is pressurized more than atmospheric pressure, Since micropore is filled up with molten metal, also as opposed to the micropore of a high aspect ratio, metal restoration is possible also to the micropore which has not been penetrated as well as the penetrated micropore, and metal restoration which openings, such as ** (**), do not produce can be performed. When filling up the penetrated micropore with metal and forming a penetrating electrode, a good penetrating electrode without an opening can be created.

[Translation done.]

TECHNICAL FIELD

[The technical field belonging to an invention] This invention relates to the metal filling apparatus and metal filling method to micropore which fill up with metal the micropore of a high aspect ratio which opened especially in the silicon substrate etc. about the metal filling method and metal filling apparatus of detailed space, for example, micropore, a detailed crevice, etc. which were formed in the work.

[Translation done.]

PRIOR ART

[Description of the Prior Art]As a case where metal restoration is conventionally carried out to the detailed space formed in the workpiece (henceforth a work), For example, when a penetrating electrode (beer hall electrode) is formed in a silicon substrate by the manufacturing process of a silicon IC chip etc., Plating which opens the breakthrough for penetrating electrodes in a silicon substrate, inserts this silicon substrate in the molten metal (plating solution) to which melting of the metal for conductors was carried out, and is filled up with molten metal in a breakthrough is common.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]According to this invention, the detailed space of various sections in various works can be filled up with metal. Insert in a molten-metal tub the silicon substrate which has micropore especially, a glass material, etc. within the vacuum chamber decompressed to vacuum pressure, and after these reach the almost same temperature as molten metal, the inside of a vacuum chamber is pressurized more than atmospheric pressure, Since micropore is filled up with molten metal, also as opposed to the micropore of a high aspect ratio, metal restoration is possible also to the micropore which has not been penetrated as well as the penetrated micropore, and metal restoration which openings, such as ** (**), do not produce can be performed. When filling up the penetrated micropore with metal and forming a penetrating electrode, a good penetrating electrode without an opening can be created.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]however, since micropore is deep and the until penetration of the molten metal cannot be carried out, when a breakthrough is the micropore of a high aspect ratio (hole depth / opening diameter), For example, as shown in drawing 7, the molten metal 3 focuses near the entrance of the micropore 2 of the silicon substrate 1, grow up, and an opening produces inside, or, Since uniform metal restoration without an opening -- ** (**) 4 is made to the molten metal 3 in the micropore 2 -- was not able to be performed as shown in drawing 8, it was difficult to create a good penetrating electrode.
[0004]By the way, if it, for example, tries to perform high-density three-dimensional mounting which laminates a silicon IC chip, it may be necessary to form the penetrating electrode for connecting the circuit pattern formed in the rear surface of the silicon substrate of one sheet but, and, Since the breakthrough which opens in a silicon substrate will turn into micropore which is a high aspect ratio deeply if it is going to form this penetrating electrode by the above-mentioned conventional method, it is difficult as above-mentioned to fill up metal into this micropore with plating, and to form a penetrating electrode.
[0005]This invention was made in light of the above-mentioned circumstances, and an object of this invention is to provide the metal filling apparatus and method of making it possible to fill up with metal without an opening the detailed space formed into works, such as a silicon substrate, for example, micropore.

[Translation done.]

MEANS

[Means for Solving the Problem]Claim 1 this invention which solves an aforementioned problem is characterized by an invention of a metal filling apparatus to detailed space comprising the following, in order to decompress inside of a vacuum chamber and said vacuum chamber to vacuum pressure.
Decompressing means.
A molten-metal tub arranged in said vacuum chamber.
A heater for carrying out heat melting of the metal in said molten-metal tub.
An arm for work immobilization for clamping a work with detailed space which it is going to fill up with metal, and inserting into a molten-metal tub in said vacuum chamber, and a force means for pressurizing inside of a vacuum chamber more than atmospheric pressure, after inserting a work into a molten-metal tub.

[0007]In a metal filling apparatus to detailed space of claim 1, claim 2 formed an opening and closing cover of a hinge style in an upper face part of a vacuum chamber, and provided an arm supporting part which supports a shank of an arm for work immobilization in a mode which penetrates said opening and closing cover so that a slide is possible in said opening and closing cover.
[0008]Claim 3 is the method of filling up with metal detailed space formed in a work, decompress first ambient pressure of a work which it is going to fill up with metal, and, subsequently a reduced pressure state has been maintained. Said work is inserted in molten metal, subsequently ambient pressure of said molten metal is pressurized, said detailed space is filled up with molten metal according to an ambient pressure difference before and behind metal insertion of a work, and subsequently, a work is pulled up from a molten-metal tub, and is cooled.
[0009]In claim 3, said detailed space formed in a work claim 4, Are micropore or an opening and said work is accommodated in a vacuum chamber, Subsequently, inside of a vacuum chamber is decompressed to vacuum pressure, subsequently to a molten-metal tub in a vacuum chamber said work is inserted, after a work reaches the same temperature as molten metal, inside of a vacuum chamber is pressurized more than atmospheric pressure, subsequently, a work is pulled up from a molten-metal tub, and air cooling is carried out.
[0010]
[Embodiment of the Invention]Hereafter, an embodiment of the invention is described with reference to drawing 1 - drawing 6. Drawing 1 is a partial notching front view of the important section of the metal filling apparatus 10 of one embodiment of this invention. In the figure, 11 is a vacuum chamber. The vacuum chamber 11 is connected to the vacuum pump apparatus 14 via the siphon 13 which is connected to the opening 11a of a pars basilaris ossis occipitalis, and has the valve 12 for vacuum opening and closing on the way. The vacuum chamber 17 for buffers which is open for free passage by the opening 16 which can be opened and closed by the shutter 15 is formed in the upper part of the vacuum chamber 11. This vacuum chamber 17 for buffers is also connected to said vacuum pump apparatus 14 via the siphon 18 for vacuum rough length with the valve 18a for

vacuum rough length. The shutter opening-and-closing mechanism for opening and closing the shutter 15 by the operation from the outside omitted the graphic display. The vacuum chamber 11 and the vacuum chamber 17 for buffers are connected to the nitrogen gas cylinder which is not illustrated as a force means which pressurizes an inside more than atmospheric pressure, respectively via the nitrogen introducing pipes 19 and 20 with the valves 19a and 20a for nitrogen introduction. The vacuum chamber 11 is formed on the case 21 which provided the power supply which operates this metal filling apparatus 10, and control and a final controlling element.

[0011]The molten-metal tub 23 is arranged in said vacuum chamber 11, and the heater 24 for carrying out heat melting of the metal in the molten-metal tub 23 to the surface part is formed. 3 shows molten metal. It is the structure which formed the work clamp 29 at the tip of the arm 27 for work immobilization and the long shank 28 which grasp the work 1 with the micropore which it is going to fill up with metal, In the mode which penetrates the opening and closing cover 30 to the arm supporting part 31 provided in the opening and closing cover 30 of the hinge style provided in the upper face part of the vacuum chamber 17 for buffers, the shank 28 of the arm 27 for work immobilization is supported so that a slide is possible. The atmospheric-air-introduction valve 32 and the relief port 33 are established in the opening and closing cover 30.

[0012]With reference to the procedure filled up with metal, the above-mentioned metal filling apparatus 10 also explains drawing 2 (b), (**), and (**) to the micropore which opened in the silicon substrate etc. Where the shutter 15 is shut, the opening and closing cover 30 is opened so that the vacuum chamber 11 may not be directly open for free passage with the atmosphere. Where the opening and closing cover 30 is opened like the two-dot chain line of drawing 1, for example, it has the micropore 2, the silicon substrate (work) 1 is grasped by the work clamp 28 of the arm 27 for work immobilization. The shank 28 of the arm 27 for work immobilization is made to project greatly from the surface of the opening and closing cover 30, and the work clamp 29 is made to approach the inner surface of the opening and closing cover 30 in this stage. Subsequently, the opening and closing cover 30 is rotated like an arrow, and it shuts, and binds tight and seals with the bolt 34. Subsequently, vacuum chamber 17 inside for buffers is vacuum-rough-lengthened via the siphon 18 for vacuum rough length with the vacuum pump apparatus 14. Subsequently, the shutter 15 is opened. Subsequently, open the valve 12 for vacuum opening and closing, and the vacuum pump apparatus 14 is operated, Vacuum suction of the inside of the vacuum chamber 11 and the vacuum chamber 17 for buffers is carried out via the siphon 13, and it decompresses to a vacuum pressure 10^{-2} - 10^{-3}Pa (Pascal) grade (this stage is shown in the drawing 2 (**)). The vacuum pressure sensor 36 detects vacuum pressure.

[0013]Subsequently, it heats with the heater 24, melting of the metal in the molten-metal tub 23 is carried out, and the silicon substrate 1 is inserted into the molten metal 3. Although it is good to use metal with comparatively low steam pressure, such as eutectic solder of indium, tin, or golden-tin, as metal with which it is filled up, it is not limited to them in particular. It waits enough after insertion until the silicon substrate 1 reaches the same temperature as the molten metal 3. Then, the valves 19a and 20a for nitrogen introduction are opened, nitrogen from a nitrogen gas cylinder is introduced in the vacuum chamber 11 and the vacuum chamber 17 for buffers, and an inside is pressurized to a 2 - $5x10^5$Pa (2 - 5 kgf/cm^2) grade. This application of pressure is filled up with the molten metal 3 in the micropore 2, as typically shown in drawing 3 (this stage is shown in the drawing 2 (**)).

[0014]Then, the silicon substrate 1 is pulled up from the molten-metal tub 23 (this stage is shown in the drawing 2 (**)), it takes out besides the vacuum chamber 11, and air cooling is carried out at a room temperature. Thereby, the metal filling work to the micropore 2 of the silicon substrate 1 is completed.

[0015]The example which filled up the micropore of each following work with metal using the above-mentioned metal filling apparatus 10 is shown in drawing 4 - drawing 6. Drawing 4 - drawing 6 sketch

the microphotograph of the section for the detailed pore filled up with metal. The example shown in drawing 4 is restoration of the tin 3 to the micropore 2 15 micrometers in diameter, and 360 micrometers in depth (aspect ratio 24) formed in the silicon substrate 1. The micropore 2 was formed on the silicon substrate with photoelectrical solution grinding method. It fills up with the tin 3 that there is no opening in the micropore 2 as the graphic display. Silicon oxide is formed in the inner surface of a breakthrough although not illustrated in particular.
[0016]The example shown in drawing 5 is restoration of the tin 3 to the micropore 2 40 micrometers in diameter, and 100 micrometers in depth (aspect ratio 2.5) formed in the silicon substrate 1. The micropore 2 was formed on the silicon substrate by ICP-RIE (Inductively Coupled Plasma-Ractive Ion Etching). It fills up with the tin 3 that there is no opening in the micropore 2 as the graphic display.
[0017]The example shown in drawing 6 is restoration of the tin 3 to the micropore 2 0.1 mm in diameter, and 35 mm in depth (aspect ratio 350) formed in the glass rod 1. It fills up with the tin 3 that there is no opening in the micropore 2 as the graphic display.
[0018]The metal restoration which metal restoration is possible and openings, such as ** (**), do not produce to the micropore of a high aspect ratio like each of above-mentioned examples by this invention is possible. Although the example which fills up metal with each example into the micropore which has not been penetrated was shown, metal restoration is still easier if it is a breakthrough. Therefore, when forming a penetrating electrode in a silicon substrate etc., a penetrating electrode without an opening can be manufactured.
[0019]Since the vacuum chamber 17 for buffers which is open for free passage to the vacuum chamber 11 via the opening 16 which can be opened and closed in the above-mentioned metal filling apparatus 10 not only by the vacuum chamber 11 which arranges the molten-metal tub 23 but by the shutter 15 is formed, Without putting the vacuum chamber 11 to the open air directly, it can carry out to above-mentioned metal filling work, therefore the molten metal 3 in the molten-metal tub 23 can prevent touching on the open air and oxidizing certainly.
[0020]Although metal restoration is carried out to the micropore which opened in a silicon substrate or glass in the example described above, the resin etc. which are comparatively excellent in heat resistance and do not melt in metal melting temperature, such as ceramics, Teflon (registered trademark) (fluoro-resin), polyimide, are employable as other work materials. Incidentally, the melting temperature of tin will become applicable [this invention], if it is construction material which does not melt easily in metaled melting temperature in this way, although the melting temperature of about 230 ** and indium changes [the melting temperature of about 157 ** and golden-tin] with ratios into a metaled ratio. Since this invention carries out metal restoration to detailed space according to the ambient pressure difference before and behind metal insertion, existence of a pressure differential is important and the absolute value of order ambient pressure is not limited to an example. It is not limited to the micropore in the silicon which regards as the detailed space in this invention formed in the work in a section which is illustrated, and is straightly prolonged to one way. For example, also when the hole is crooked on the way, it can apply. For example, in the multilayer substrate which laminated two or more silicon substrates as a tabular work, although there is also a pattern in which a hole is crooked on the way along the inner surface of a work (seeing from a section), according to [such even case] this invention, the metal restoration to a crookedness hole is attained. Also when the section outline of a hole branches into arborescence, the metal restoration to an arborescence tip part is possible. According to this invention, the metal restoration to a crevice is also attained. For example, in the work which consists of a structure of composite or a single member combined and depended, when carrying out metal restoration to the detailed crevice (gap) formed into these works, it can apply.

[Translation done.]

DESCRIPTION OF DRAWINGS

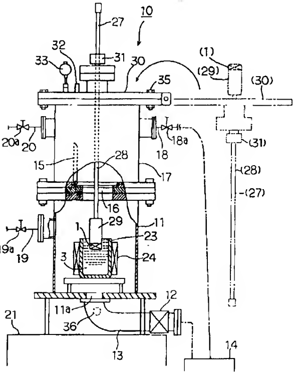
[Brief Description of the Drawings]
[Drawing 1]It is a partial notching front view of the important section of the metal filling apparatus to the detailed space of one embodiment of this invention.
[Drawing 2]With the metal filling apparatus of drawing 1, it is a figure explaining the process of performing metal restoration to the micropore of a silicon substrate, and is carried out in order of (b), (**), and (**).
[Drawing 3]It is a mimetic diagram explaining the situation where micropore is filled up with molten metal in the process of (**) of drawing 2, and before (b) pressurizes the inside of a vacuum chamber, (**) shows, after pressurizing.
[Drawing 4]It is a sectional view for the detailed pore which explains the experimental result which filled up the micropore of the silicon substrate with tin by this invention method, and was filled up with tin.
[Drawing 5]It is a sectional view for the detailed pore which explains other experimental results which filled up the micropore of the silicon substrate with tin by this invention method, and was filled up with tin.
[Drawing 6]It is a sectional view for the detailed pore which explains the experimental result which filled up the micropore of the glass rod with tin by this invention method, and was filled up with tin.
[Drawing 7]It is a figure explaining a short-shot state when metal is filled up with the conventional metal filling method into micropore, and is a typical sectional view for the detailed pore filled up with the metal of the silicon substrate.
[Drawing 8]It is a figure explaining the short-shot state which ** when metal was filled up with the conventional metal filling method into micropore produced, and is a typical sectional view for the detailed pore filled up with the metal of the silicon substrate.
[Description of Notations]
2 Micropore (detailed space)
3 Molten metal
10 Metal filling apparatus
11 Vacuum chamber
11a Opening
12 The valve for vacuum opening and closing
13 Siphon
14 Vacuum pump apparatus
15 Shutter
16 Opening
17 The vacuum chamber for buffers
18 Suction management for buffers
19 and 20 Nitrogen introducing pipe

19a and 20a Valve for nitrogen introduction
23 Molten-metal tub
24 Heater
27 The arm for work immobilization
28 Shank
29 Work clamp
31 Arm supporting part
36 Vacuum pressure sensor

[Translation done.]

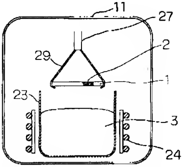
DRAWINGS

[Drawing 1]

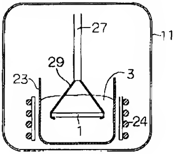


[Drawing 2]

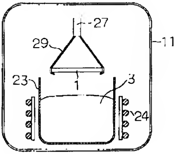
(イ)



(ロ)

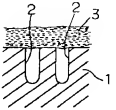


(ハ)

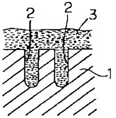


[Drawing 3]

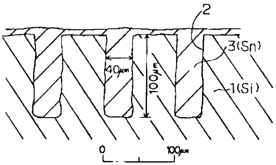
(イ)



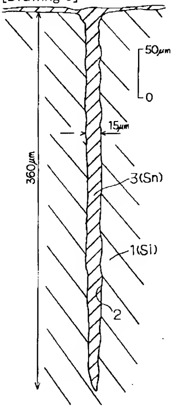
(ロ)



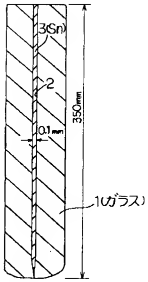
[Drawing 4]



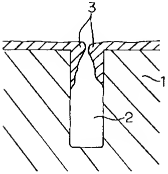
[Drawing 5]



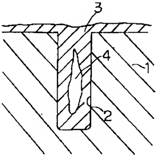
[Drawing 6]



[Drawing 7]



[Drawing 8]



[Translation done.]